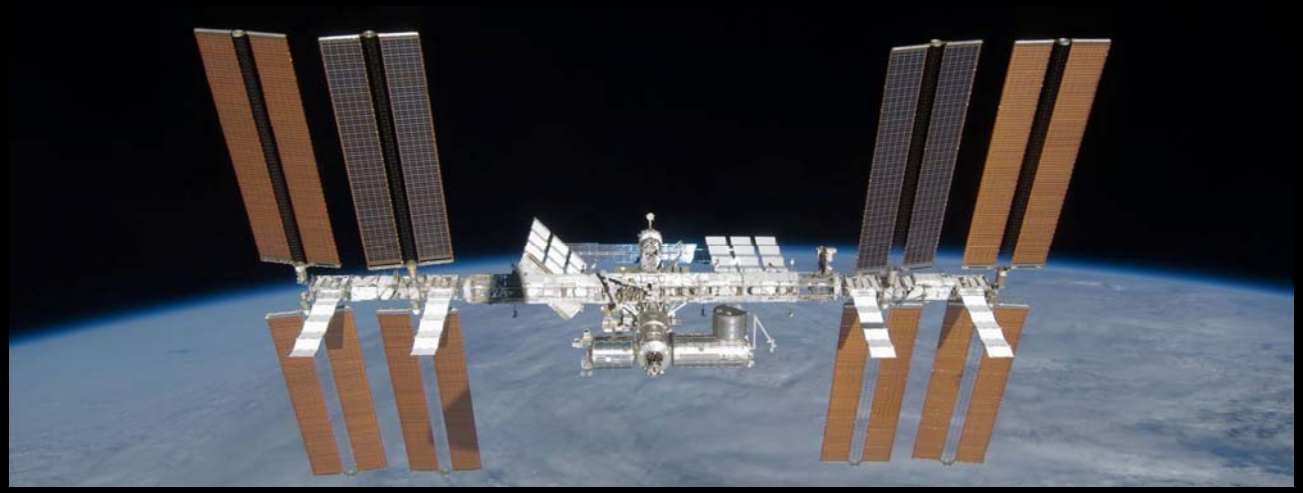

ENGINEERING ABOVE AND BEYOND

Written communication in the technical workplace…

Vanderbilt University
October 20, 2014

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NASA-George C. Marshall Space Flight Center

Contents

- Environmental control and life support systems (ECLSS)
  - Some basics
- How does effective written communication fit?
  - The fundamentals
- Conclusion
- Helpful sources

The Daily Challenge

Inputs

- Oxygen
  0.84 kg (1.84 lb)
- Food Solids
  0.62 kg (1.36 lb)
- Water in Food
  1.15 kg (2.54 lb)
- Food Prep Water
  0.76 kg (1.67 lb)
- Drink
  1.62 kg (3.56 lb)
- Metabolized Water
  0.35 kg (0.76 lb)
- Hand/Face Wash Water
  4.09 kg (9.00 lb)
- Shower Water
  2.73 kg (6.00 lb)
- Urinal Flush
  0.49 kg (1.09 lb)
- Clothes Wash Water
  12.50 kg (27.50 lb)
- Dish Wash Water
  5.45 kg (12.00 lb)

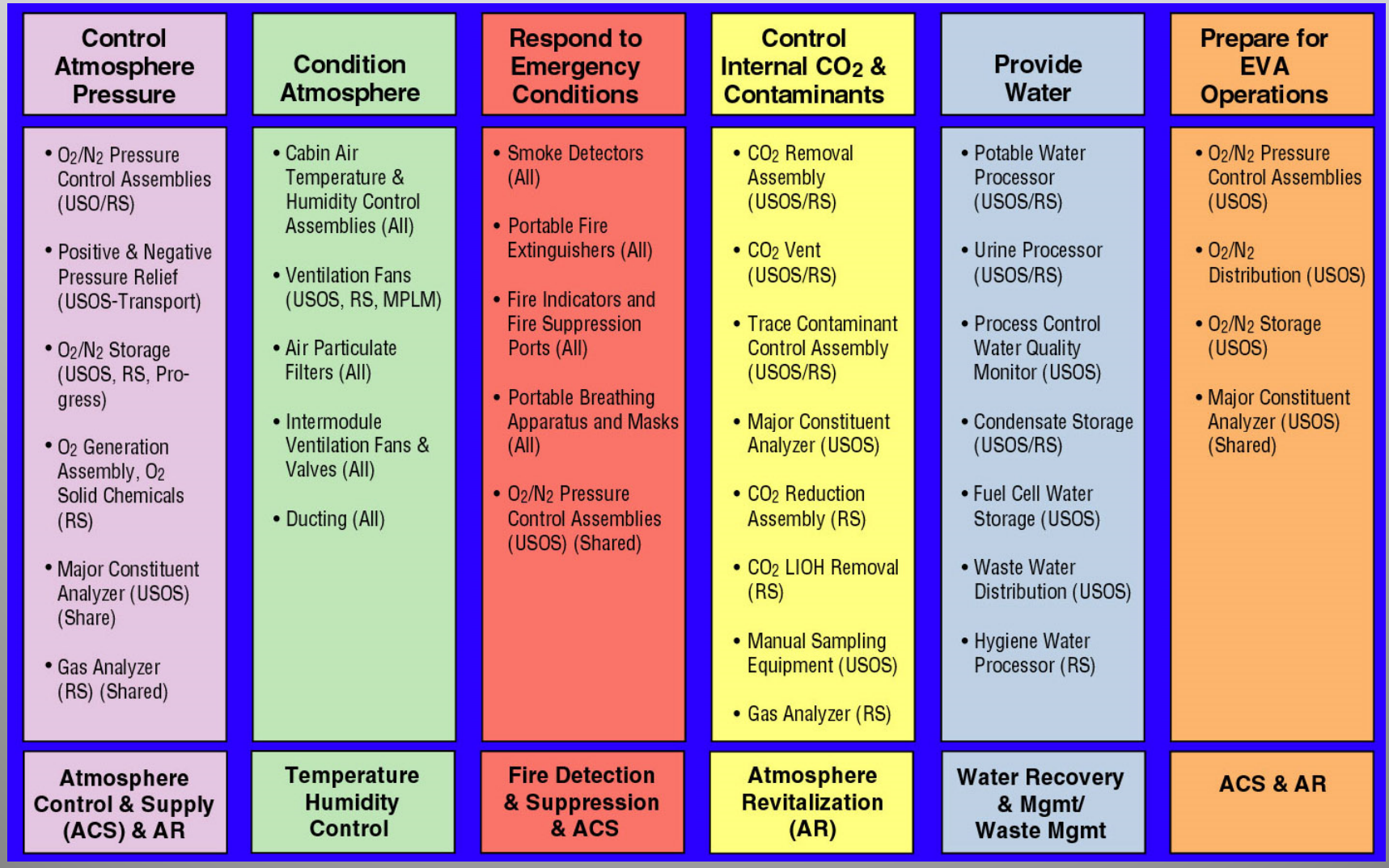
Total = 30.60 kg (67.32 lb)

Outputs

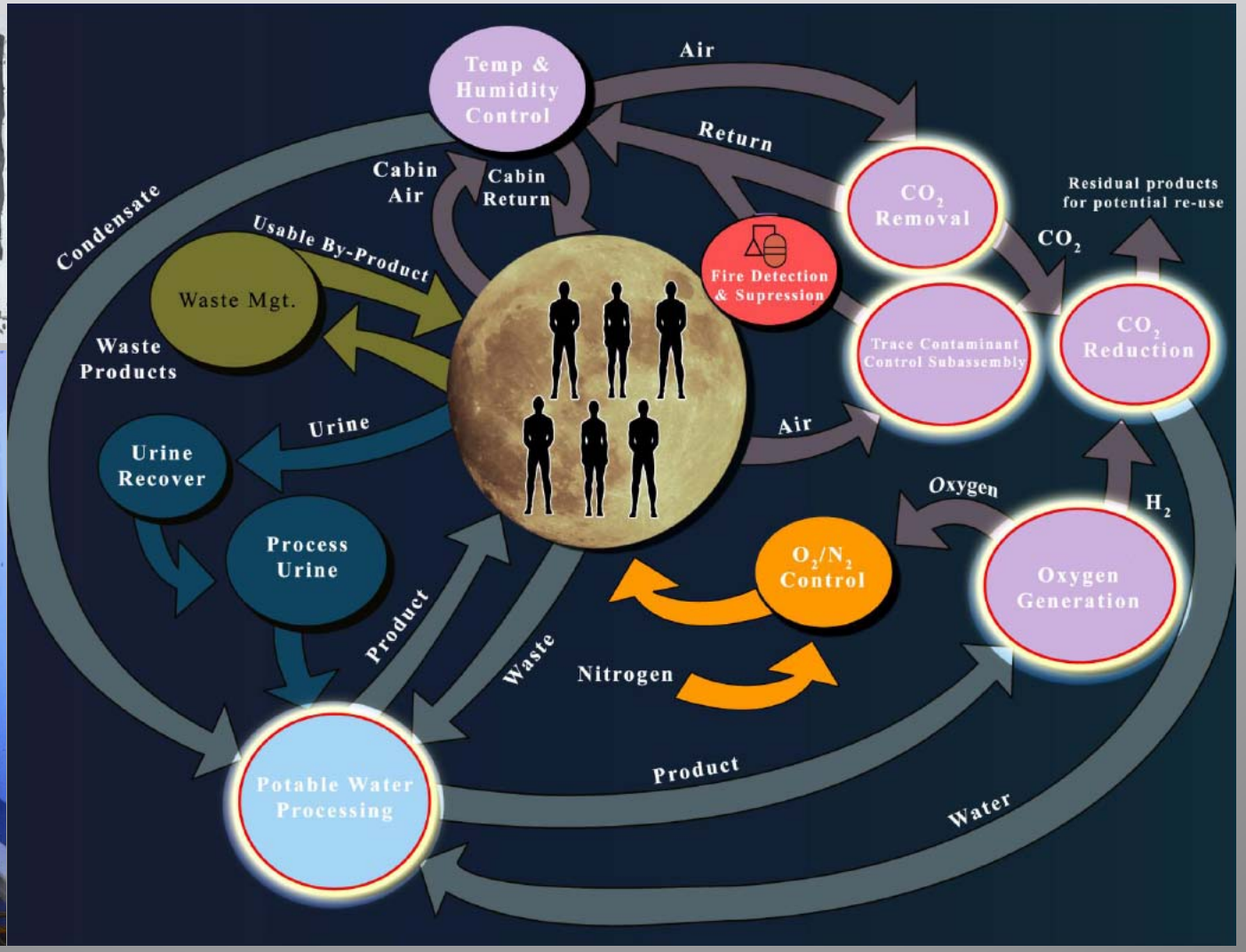
- Carbon Dioxide
  1.00 kg (2.20 lb)
- Respiration & Perspiration Water
  2.28 kg (5.02 lb)
- Food Preparation, Latent Water
  0.036 kg (0.08 lb)
- Urine
  1.50 kg (3.31 lb)
- Urine Flush Water
  0.49 kg (1.09 lb)
- Feces Water
  0.091 kg (0.20 lb)
- Sweat Solids
  0.018 kg (0.04 lb)
- Urine Solids
  0.059 kg (0.13 lb)
- Feces Solids
  0.032 kg (0.07 lb)
- Hygiene Water
  12.58 kg (27.68 lb)
- Clothes Wash Water
  11.90 kg (26.17 lb) liquid
  0.60 kg (1.33 lb) vapor

Total = 30.60 kg (67.32 lb)

ECLS System Functions

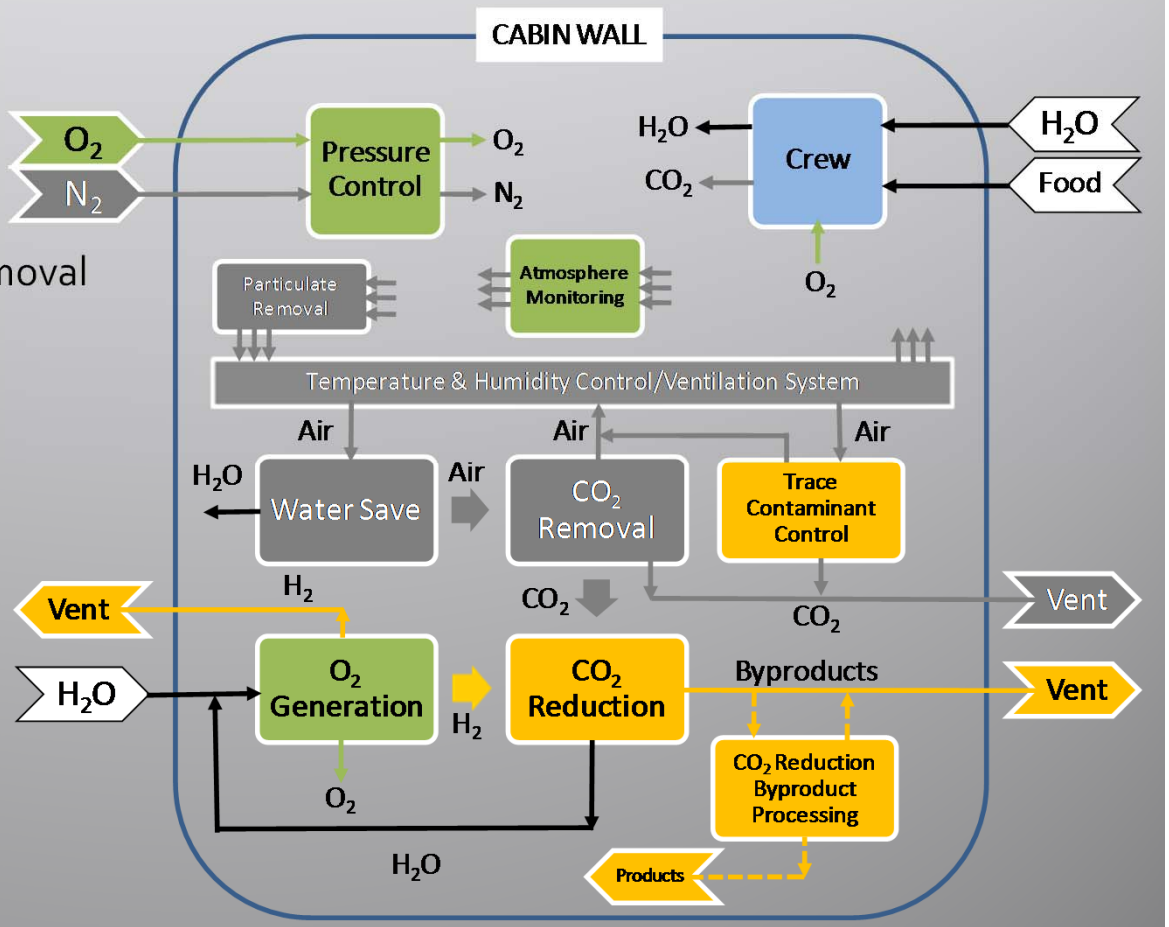


ECLS System Functional Interactions

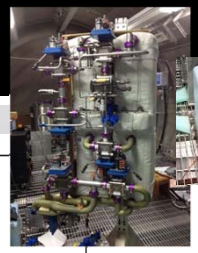


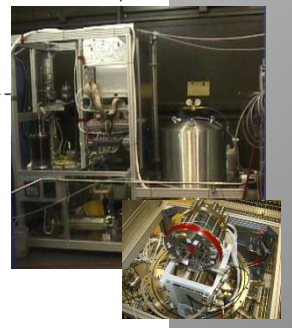
Process Types & Unit Operations

- Separations
  - Physical adsorption
    - Process gas drying
    - CO_2 removal
    - Gaseous contaminant removal
  - Absorption
  - Filtration
- Reactions
  - Chemical adsorption
  - Catalytic oxidation
  - Catalytic reduction
  - Electrochemical
  - Plasma
- Resource management
  - Gas storage & conditioning
  - Atmospheric gas production & recycling



ISS AR Process Architecture





Environmental Monitoring

Cabin Atmosphere

Variable Bypass

20-30 CFM

Carbon Dioxide Removal Assembly (CDRA)

Desiccant Bed

Sorbent Bed

Desiccant Bed

Sorbent Bed

Air Save Pump

Compressor

CO_2 Accumulator

Sabatier CRA

Facility N_2

Facility H_2

Vent

CO_2 Vent

CH_4 H_2O CO_2

TCCS Development Unit 1.1

9 CFM

Charcoal Bed Assembly

High-Temp Catalytic Oxidizer

2.7 CFM

Sorbent Bed Assembly

Oxygen Generation Assembly (OGA)

Deionizing Bed

Deionizing Bed

Facility H_2O

Facility N_2

Facility O_2

ISS Performance Basis
Hardware Schematic
Draft 4
5-15-2012

Symbols

- Packed bed
- Heater
- Cooler
- Recuperative Heat exchanger
- Condensing Heat exchanger
- Check valve
- Three-way automatic control valve
- Two-way hand-operated valve
- Dewpoint analyzer
- Carbon dioxide analyzer
- Pump
- Compressor
- Blower
- Flowmeter
- Oxygen analyzer
- Electrolysis Stack
- Accumulator
- Separator
- Orifice

Successful Engineering…

or any worthwhile endeavor requires…

COMMUNICATION

"When I began working in industry, I learned quickly how written communication is tremendously important. An engineer can have great ideas or work, but ideas will never get implemented or noticed if they are not communicated to those who make the decisions."

Gregory N. Tragitt, BE'78
Vanderbilt Engineering, Fall 2011

"Give me six hours to chop down a tree and I will spend the first four sharpening the axe."

Abraham Lincoln

Communicating is a Process…

Technical Writing Products

TECHNICAL

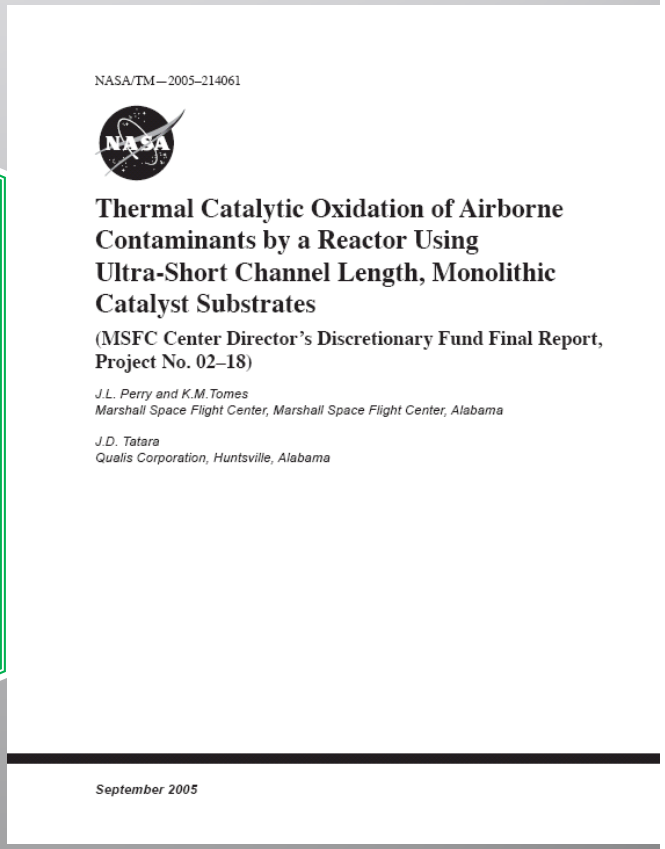
- **Specifications and standards**
  - *Performance*
  - *Interfaces*
  - *Environments*
  - *Materials*
  - *ISO 9000 certification*
- **Architectural descriptions**
- **Operations documents**
  - *Procedures*
  - *Manuals*
- **Developmental documents**
  - *Experiment requirements*
  - *Experiment procedures*
  - *Technical reports*
  - *Intellectual property*

CONTRACT UAL

- **Customer**
  - *Statement of work*
  - *Request for proposal*
  - *Technical evaluation*
  - *Contracts and protocols*
  - *Task agreements*
  - *Memoranda of agreement*
- **Product Provider**
  - *Proposals*
  - *Contracts and protocols*
  - *Technical reports*

OTHER FORMS

- Product brochures
- Product technical literature
- News items
- Status reports
- Meeting minutes
- Letters
  - *transmittal*
  - *informative*
  - *persuasive*



NASA/TM—2005–214061

Thermal Catalytic Oxidation of Airborne Contaminants by a Reactor Using Ultra-Short Channel Length, Monolithic Catalyst Substrates

(MSFC Center Director's Discretionary Fund Final Report, Project No. 02–18)

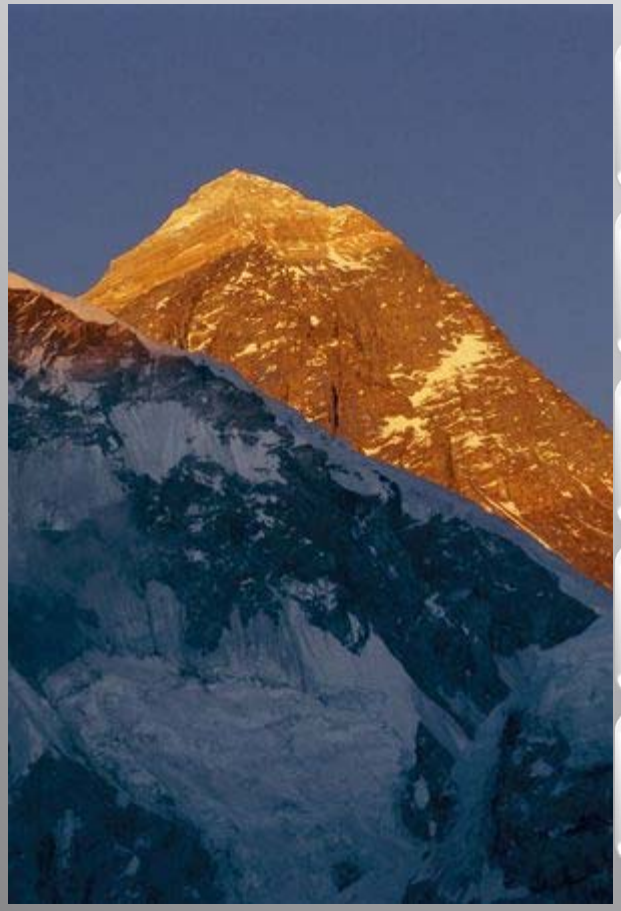
J.L. Perry and K.M.Tomes
Marshall Space Flight Center, Marshall Space Flight Center, Alabama

J.D. Tatara
Qualis Corporation, Huntsville, Alabama

September 2005

Vital Writing Elements

Impediments to Effective Writing

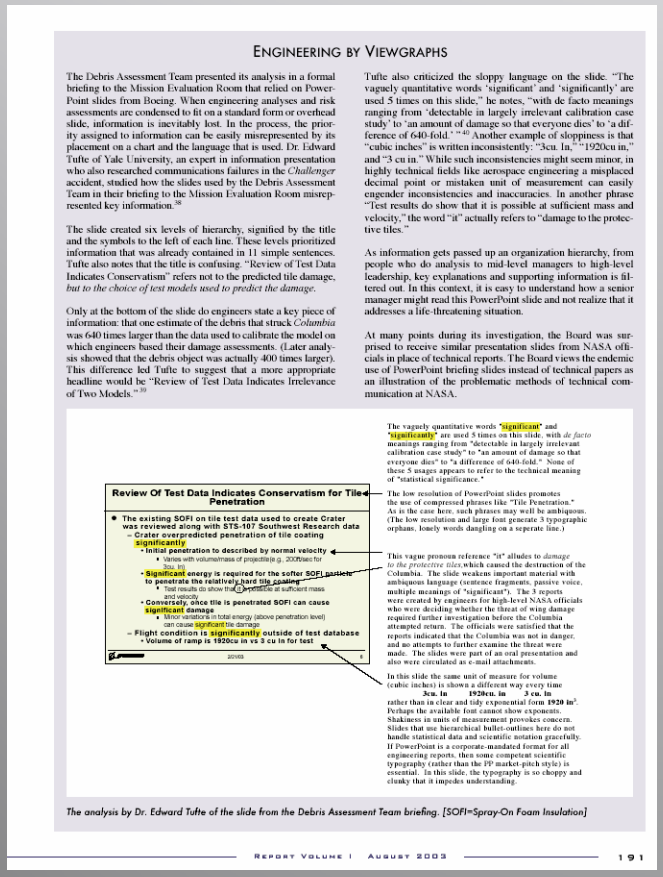


Personal	• Do not like to write—it's hard, not fun
Organizational	• Project views as unimportant • Pressure to move to next task
Budget	• No project resources allotted (time)
Schedule	• Planning and priorities
Cultural	• Perception there is no reward

Consequences

The Shuttle *Columbia*—Findings from the CAIB

"The Board views the endemic use of PowerPoint briefing slides instead of technical papers as an illustration of the problematic methods of technical communication at NASA." – CAIB Report



ENGINEERING BY VIEWGRAPHS

The Debris Assessment Team presented its analysis in a formal briefing to the Mission Evaluation Room that relied on PowerPoint slides from Boeing. When engineering analyses and risk assessments are condensed to fit on a standard form or overhead slide, information is inevitably lost. In the process, the priority assigned to information can be easily misrepresented by its placement on a chart and the language that is used. Dr. Edward Tufte of Yale University, an expert in information presentation who also researched communications failures in the *Challenger* accident, studied how the slides used by the Debris Assessment Team in their briefing to the Mission Evaluation Room misrepresented key information.[38]

The slide created six levels of hierarchy, signified by the title and the symbols to the left of each line. These levels prioritized information that was already contained in 11 simple sentences. Tufte also notes that the title is confusing. "Review of Test Data Indicates Conservatism" refers not to the predicted tile damage, *but to the choice of test models used to predict the damage.*

Only at the bottom of the slide do engineers state a key piece of information: that one estimate of the debris that struck *Columbia* was 640 times larger than the data used to calibrate the model on which engineers based their damage assessments. (Later analysis showed that the debris object was actually 400 times larger). This difference led Tufte to suggest that a more appropriate headline would be "Review of Test Data Indicates Irrelevance of Two Models."[39]

Tufte also criticized the sloppy language on the slide. "The vaguely quantitative words 'significant' and 'significantly' are used 5 times on this slide," he notes, "with de facto meanings ranging from 'detectable in largely irrelevant calibration case study' to 'an amount of damage so that everyone dies' to 'a difference of 640-fold.'"[40] Another example of sloppiness is that "cubic inches" is written inconsistently: "3cu. In," "1920cu in," and "3 cu in." While such inconsistencies might seem minor, in highly technical fields like aerospace engineering a misplaced decimal point or mistaken unit of measurement can easily engender inconsistencies and inaccuracies. In another phrase "Test results do show that it is possible at sufficient mass and velocity," the word "it" actually refers to "damage to the protective tiles."

As information gets passed up an organization hierarchy, from people who do analysis to mid-level managers to high-level leadership, key explanations and supporting information is filtered out. In this context, it is easy to understand how a senior manager might read this PowerPoint slide and not realize that it addresses a life-threatening situation.

At many points during its investigation, the Board was surprised to receive similar presentation slides from NASA officials in place of technical reports. The Board views the endemic use of PowerPoint briefing slides instead of technical papers as an illustration of the problematic methods of technical communication at NASA.

The analysis by Dr. Edward Tufte of the slide from the Debris Assessment Team briefing. [SOFI=Spray-On Foam Insulation]

REPORT VOLUME I AUGUST 2003 191

- Analysis findings presented in management briefing
- Title is confusing
- Inevitable Information loss
- Key information is misrepresented and demoted in hierarchy
- Most important item buried at the bottom of the slide
- Vaguely quantitative wording used
  - "Significantly" used 6 times to mean different things
- Inconsistent units of measure

Conclusion

- Writing is essential to technical success
  - Provides a foundation for other means of communication
  - Preserves corporate memory
  - Ensures that you get what you pay for
- Successful writing takes time
  - More than 90% of a job may be dedicated to documentation in some form
  - Practice by doing
- Strive to overcome obstacles
  - Set aside time to plan
  - Ensure project resources and schedules allow adequate time
  - Recognize that the rewards are gained over time as your products establish your credibility